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Labrador Brook Trout Mark Recapture and Outfitter Logbook Program; a subcomponent study of the Trans Labrador Highway Phase III environmental Assessment

Programme de marquage et recapture de l'omble de fontaine du Labrador et de livre de bord des pourvoyeurs : un volet de l'évaluation environnementale du projet de route Translabradorienne (Phase III)

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ABSTRACT

During the summer of 2007 both a logbook and mark-recapture program were initiated to establish estimates for catch per unit of effort, composition and commercial population size of six trophy brook trout fisheries located on the Eagle River Watershed, Labrador, Canada. Significant differences existed among lakes for both length and weight of catch. Catch rates did not differ among five lakes (0.64 fish per hour). However, one lake had a mean catch rate more than twice that of the other five (1.97 fish per hour). Weight and length of catch significantly differed among the six lodges. Overall, the mean weight of an angled fish for the watershed was 4.27 lb (N = 416, max. = 8.25 lb, min. = 0.5 lb). The average length was 50.2 cm (N = 344 max. = 61.0 cm, min. = 24.1 cm). Comparisons of fish length and weight classes from standardized sampling indicate that brook trout from the Eagle River tend to be larger than trout sampled from neighbouring watersheds. Preliminary results for the mark recapture portion of the study were insufficient to give reliable population estimates for five of the six lodges surveyed.

RÉSUMÉ

Au cours de l'été 2007, les programmes de livre de bord et de marquage et recapture ont été lancés afin d'établir des estimations de prises par unité d'effort, de composition et de taille de la population commerciale pour six sites de pêche d'omble de fontaine trophée dans le bassin versant de la rivière Eagle du Labrador, au Canada. Il existe des écarts importants entre les lacs en termes de longueur et de poids des prises. Le taux de capture ne varie pas vraiment dans cinq de ces lacs (0,64 poisson / heure). Le sixième présentait cependant un taux de capture deux fois supérieur aux cinq autres (1,97 poisson / heure). Le poids et la longueur des prises variaient de façon importante entre les six sites. Globalement, le poids moyen des poissons capturés à la ligne dans le bassin versant était de 4,27 lb (N = 416, max. = 8,25 lb, min. = 0,5 lb). La longueur moyenne se situait à 50,2 cm (N = 344 max. = 61,0 cm, min. = 24,1 cm). La comparaison des catégories de poids et de longueur des poissons à partir d'échantillons standard indique que l'omble de fontaine de la rivière Eagle est généralement plus gros que les échantillons provenant des bassins versants voisins. Les résultats préliminaires de la partie marquage et recapture de l'étude sont insuffisants pour permettre une estimation fiable de la population pour cinq des six sites étudiés.

INTRODUCTION

Phase III of the Trans-Labrador highway, linking Cartwright Junction to Happy Valley Goose Bay, will create access to Goose Bay from the isolated communities located on the lower east coast of Labrador. The creation of this road will also provide Newfoundlanders and Labradoreans, as well as tourists, access to vast areas of pristine watershed that were formerly inaccessible. The Provincial Wildlife Division as well as native groups, outfitters and residents had expressed concern over the potential impacts of increased access on fisheries resources that exist in the area. To address this concern a monitoring program was established for fish populations in affected watersheds to provide baseline data for 1) assessing the long-term impacts of increased access on fish populations and 2) development of management strategies to conserve fish populations should they become necessary.

As part of this sampling initiative a subcomponent study was implemented in 2005 to monitor the health of brook trout *Salvelinus fontinalis*, fisheries in the Eagle River watershed. The study involved the establishment of a logbook program for the outfitting industry situated on lakes of the catchment. The logbook was designed to assist in the assessment of their sport fisheries; specifically, the logbook would collect baseline data on numbers of fish caught, fishing effort and body measures of the fish being angled.

Logbooks have been employed in other studies to gather detailed information to provide catch data, both for annual shifts and also for temporal trends within a season (Evans 1996; Cowx et al. 1986). Logbooks have also been used by other government agencies to monitor sport fisheries. In the North West Territories logbooks were employed to assess the lake trout *Salvelinus namaycush* fisheries of Great Bear and Great Slave Lake (Yaremchuk 1986).

In 2005, a pilot logbook program was established in cooperation with three sport fishing lodges situated on lakes of the Eagle River Watershed. The experimental program was used to identify deficiencies with the logbook methodology so that when the program was later expanded, problems in its implementation could be reduced.

In 2007 the logbook program was officially launched, with six lodges participating. All participants, with the exception of one lodge which served as a control, were chosen based on their proximity to the new highway route. As part of the logbook program a mark-recapture (tagging) study was also incorporated. Through this tagging study estimates could be obtained for the population size of the commercial catch and some information on fish movements could be obtained. The following report outlines the methodology and findings of the logbook and tagging program to date.

STUDY OBJECTIVES

(1) To describe the characteristics of the commercial sport fishery for the Eagle River Watershed prior to the completion of the Trans- Labrador Highway including; catch, (number of fish kept and released), effort (hours fished), growth (length and weight of fish caught) and,

(2) To develop population estimates for the commercial catch of each lodge.

STUDY AREA

The Eagle River watershed comprises an area of 10,842 km^2. Its 81 tributaries combine for a total river length of 3548 km. The watershed is comprised of many shallow lakes, smooth steadies, and string bogs that drain off the Eagle Plateau, just south of the Mealy Mountains, into the large, fast flowing main stem of the Eagle River (Fig. 1). The river is the fifth largest in Labrador and carries a high volume of water northeast, emptying into the northwestern corner of Sandwich Bay (N 5936539; E 470762 NAD83 Z21) between the White Bear and Paradise Rivers, Labrador. The prevailing wind for the area is westerly and the climate is severe with long cold winters and short cool summers having a mean daily temperature of -23 °C for January and 13.6 °C for July, with extremes of -48 °C and 30 °C. Mean annual precipitation for the area is 760 mm and approximately half of this precipitation falls as snow (Anderson, 1985).

Vegetation in the area consists primarily of peat bog with forest growth being composed of softwoods, black spruce (*Picea mariana*) and balsam fir (Abies *balsamea*) with some white spruce (*Picea glauca*), scattered throughout. Hardwood stands consisting of trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) exist only in areas of good forest growth (Anderson 1985).

The fish species that inhabit the area first colonized approximately 17 000 years ago subsequent to the receding of the last glaciation (Prest 1969). They either colonized across land from Quebec, originating from the Mississippi refugia, or by moving up the coast, originating from the Atlantic refugia (Black et al. 1986). Because of these two points of origin there is a great richness in species diversity (Table 1).

In an effort to help conserve the trophy brook trout stocks (fish >1.36 kg) that inhabit the region, a new management zone was created for the Plateau in February of 2007. In this zone there is a reduced bag limit (six fish, or 1.13 kg plus one fish) and a possession limit that equals the daily bag limit. This is in contrast to the current limit of 12 fish plus one and a possession limit that is twice that of the daily bag limit (Fig. 1).

Table 1. Fish species found within the study area.

Family	Scientific Names	Common Names
Salmonidae	*Salvelinus fontinalis*	brook trout
	Salvelinus namaycush	lake trout
	Salvelinus alpinus	arctic char
	Salmo salar	Atlantic salmon
Esocidae	*Esox lucius*	northern pike
Cyprinidae	*Couesius plumbeus*	lake chub
	Semotilus margarita	pearl dace
	Rhinichthys cataractae	longnose dace
Catastomidae	*Catastomous catostomous*	longnose sucker
	Catostomous commersoni	white sucker
Gadidae	*Lota lota*	burbot
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback
Cottidae	*Cottus bairdi*	mottled sculpin
	Cottus cognatus	slimy sculpin

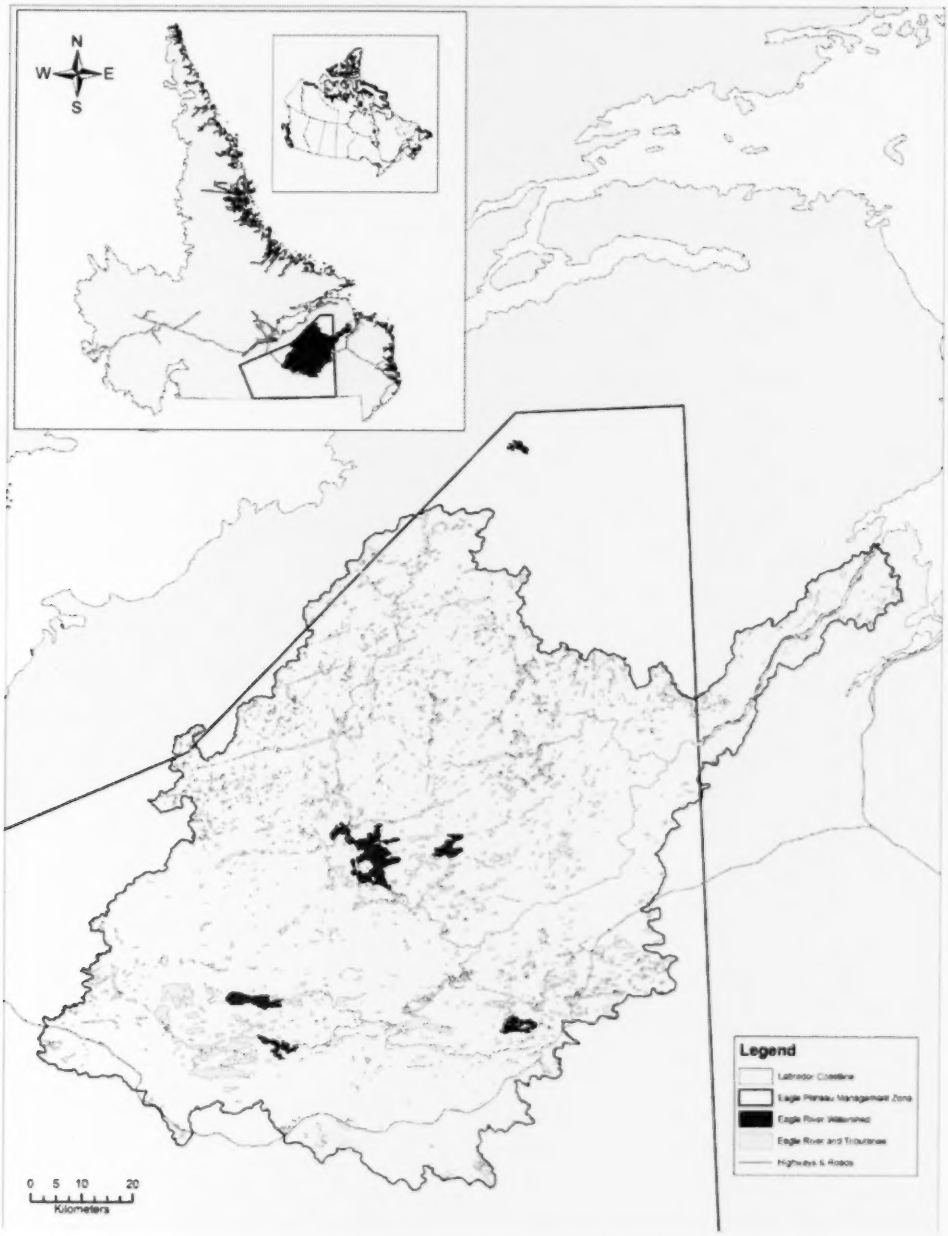

Figure 1. Map depicting an outline of the Eagle River Watershed. The straight black lines indicate the boarders of the new Eagle River Management Zone and the red line indicates Phase III of the Trans Labrador Highway. The darkened lakes indicate locations of lodges that have agreed to participate in the mark-recapture study.

METHODS

Prior to the 2007 angling season brook trout outfitters operating in proximity to the new Trans-Labrador Highway were contacted to request cooperation in the program. After contacting all available outfitters, six (of a possible nine) lodges agreed to participate in the program for 2007 (Table 2). Five lakes were located in close proximity to the new highway and one lake was far north of the highway, which served as a control site.

Table 2. Lodges which agreed to participate in the logbook program with their locations (Universal Transverse Mercator (UTM) coordinate system), and estimated distances from Phase III of the Trans-Labrador Highway (TLH).

Lodge Name	Location NAD83 Northing	Easting	Zone	Distance from TLH (km)
Awesome Lake Lodge	5959096	402177	21	93
Crooks Lake Lodge	5853939	340559	21	26
Eagle River Trout Lodge	5843998	348966	21	15
Igloo Lake Lodge	5879623	383318	21	32
Osprey Lake Lodge	5845008	393094	21	5
Park Lake Lodge	5881474	367940	21	49

The program involved two onsite visitations to each lodge, and weekly monitoring by phone for the duration of the project. The first visitation occurred prior to the beginning of the lodges' operations in June. During this visit, two guides were selected for training in the proper procedures for tagging fish. Additionally, one of the chosen guides (usually the head guide) was selected to act as a liaison for the duration of the project. Subsequently, both guides were assigned tagging kits which contained a log book, tagging gun, spare needles, and a minimum of 200 numbered tags (additional tags were made available upon request). Each lake was assigned specific coloured tags so that the lake of origin could be determined should fish be recaptured large distances from their original point of capture.

The second visitation took place in July, near or at the end of the project. During this visit progress was assessed, tagging equipment was collected and any questions or concerns expressed by the guides were addressed. Individual logbooks were also checked during this visit to identify recording errors and correct them on site, with those individuals concerned.

In total, guides were asked to participate in the program for a period of four weeks. During the first two weeks guides were asked to record, measure and tag every angled fish that was larger than 15.0 cm (fish tag numbers were also recorded in the logbook). Each brook trout was tagged with a single colour coded and numbered Floy FD-94 tag. Tags were placed just below the dorsal fin (Guy and Brown 1996).

In the last two weeks, guides were asked to measure, weigh and record every captured fish, and every recaptured fish was to have its tag number recorded. For the entire four weeks guides were also asked to record additional information which included; weather conditions, air temperatures, total time fished per trip, fishing locations, fishing method, and gear type.

In addition to the focused effort by the two primary guides, to augment the catch and effort data, logbooks and tape measures were also given to each additional guide who agreed to participate. These guides were asked to record all fishing effort (hours fished) and fish caught per trip, as well as fish lengths (and weights if possible). They were also instructed to ensure all tagged fish were recorded along with their tag numbers.

Lake attribute information, including water chemistry and bathymetry, were also collected during the first and second visits. Water chemistry work consisted of collecting profiles from various locations in each lake. This work was completed using an YSI 600QS Sonde, collecting several parameters, including temperature, specific conductivity, dissolved oxygen, depth, and pH (YSI incorporated). A minimum of four profile reading were taken at each lake from locations that best represented the lake as a whole.

Bathymetry was completed on each lake for bottom mapping and habitat assessment using a Garmin GPSMAP178C GPS Sounder unit with a 200/50KHz dual frequency, transom mount transducer to record depth and temperature. The data were collected by running diagonal transects throughout the lake with the unit mounted to the boat's stern. Depth and location were recorded at approximately 50m intervals with variations based on lake size and bottom changes.

ANALYSIS

MARK AND RECAPTURE

To calculate the population size of the commercial catch a Petersen mark recapture calculation, was used to estimate the population (Krebs 1989);

$$\hat{N} = \frac{(M+1)(C+1)}{R+1} - 1$$

where $\hat{N}$ = Population at time of marking
M = Number of individuals marked
C = Number of individuals captured after marking
R = Number of marked individuals recaptured

Once population estimates were derived, 95% confidence interval were then calculated using the following formula (Guy and Brown 2007):

95% Confidence Limit of $\hat{N}$ = MC(TV)

Where; $\hat{N}$ = Population at time of marking
MC = Number of individuals captured after marking
TV = Values are taken from Chapman's 95% CI table for population estimates with Poisson distributions

FISH GROWTH

Catch, mean lengths and weights were calculated using the fish attribute data recorded in the individual guide logbooks. ANOVAs were run on the lengths and weights to test for significant differences between the means for each lake. Where differences were detected, post hoc Scheffe tests were run to identify which lakes differed (Sokal and Rohlf 2000).

Collected fish lengths were used to calculate proportional stock density (PSD) for all lakes (Anderson 1976). Size groupings for this analysis were based on 10 cm intervals. The purpose of the PSD analysis is to determine whether there is any significant difference in the over-all size structure of brook trout populations among the lakes. Chi-square analysis was used to test for differences in the distributions (Sokal and Rohlf 2000).

Effort and capture data recorded in the logbooks were collated and catch per unit effort (CPUE) for each lake was calculated. Catch rates were calculated as fish per hour (CPUE) (Ricker 1970). To test for differences among lakes for catch rates a single ANOVA test was performed followed by a Sheffe's multiple comparison test.

WATER CHEMISTRY

Water chemistry parameters were downloaded to EcoWatch software, and then exported to spreadsheets for comparison and general analysis. Values were compared to the Canadian Water Quality Guidelines for the Protection of Aquatic Life.

LAKE ATTRIBUTE COMPONENT

Bathymetric data where downloaded to Garmin MapSource software, then exported to ARC GIS software for analysis (Environmental Systems Research Institute, INC). Using ARC Map, Workstation, and 3D Analyst bathymetry data were assessed to establish lake volumes, and utilized to create three dimensional renderings of lake bottoms, and develop bottom contour maps for each lake.

RESULTS

FISH COMPONENT

Each lodge reported the number of brook trout over six inches that were caught and marked for the tagging period and the numbers of fish, marked and unmarked that were caught after tagging ceased (Table 3). There were varying numbers of fish caught at the different lodges, with insufficient numbers of recaptures at five of the six locations. Lodge B, Lodge D and Lodge F had good numbers of marked fish (213, 303, and 250, respectively) and Lodge B had the highest number of recaptures with 30 marked fish being reported.

Table 3. Results of marking efforts by lake; showing the total number of fish marked, and the number of marked fish that were captured after marking had ceased.

Lodge	Post Marking Captures	Fish Marked	Marked Fish Recaptured
Lodge A	82	48	1
Lodge B	213	204	30
Lodge C*	75	49	6
Lodge C	86	7	1
Lodge D	303	137	8
Lodge E	65	75	1
Lodge F	250	277	5

* Indicates data acquired from the 2005 pilot study.

Using the previous data, brook trout population could not be accurately established for five of the lakes surveyed (Table 4). In cases where the numbers of recaptured confidence limits were very broad giving unreliable population estimates. Only Lodge B had sufficient numbers of marked and recaptured fish to provide a population estimate.

Table 4. Population estimates by lake with associated 95% confidence intervals. Only Lodge B (highlighted in grey) can be considered reliable.

Lodge/Lake	Population Estimate	Lower Limit (95% CI)	Upper Limit (95%CI)
Lodge A	2,033	283	76,709
Lodge B	**1,414**	**965**	**2,077**
Lodge C*	542	221	1,426
Lodge D	4,660	2,183	10,627
Lodge E	2,507	351	95,009
Lodge F	11,629	4,460	35,525

* Data from 2005 pilot program was used to obtain estimate.

Using the attribute information, means were calculated for fork lengths and whole weights (Table 5). Results of the ANOVA test indicated significant difference existed for fish length among the six lakes (df = 5, F=116.974; $P<0.001$). Results from the Scheffe's post hoc test indicate the lakes can be placed into four groupings (Fig. 3). Differences in mean fish weight also existed among the lakes (df = 5, F=173.071, $P<0.001$). The Scheffe post hoc test indicated the significant weight differences existed among four groupings. There was one lodge that crossed over two grouping (Fig. 2).

Table 5: Mean fork length (mm) and whole weight (g) estimates of captured brook trout by lake. 95 % confidence interval is also report in brackets (CI).

Lodge/Lake	Length (N)	Mean Fork Length (mm)(CI)	Weight (N)	Mean Live Weight (g) (CI)
Lodge A	124	363(345, 381)	89	736(645, 826)
Lodge B*	715	489(484, 492)	735	1,760(1,721, 1,799)
Lodge C*	86	445(428, 461)	173	1,722(1,617, 1,827)
Lodge D	138	480(470, 490)	5	2,134(1,584, 2683)
Lodge E	115	524(508, 540)	139	2,637(2,476, 2,798)
Lodge F	531	430(423, 435)	531	1,267(1,224, 1,308)

*Data from previous years were included in the estimates.

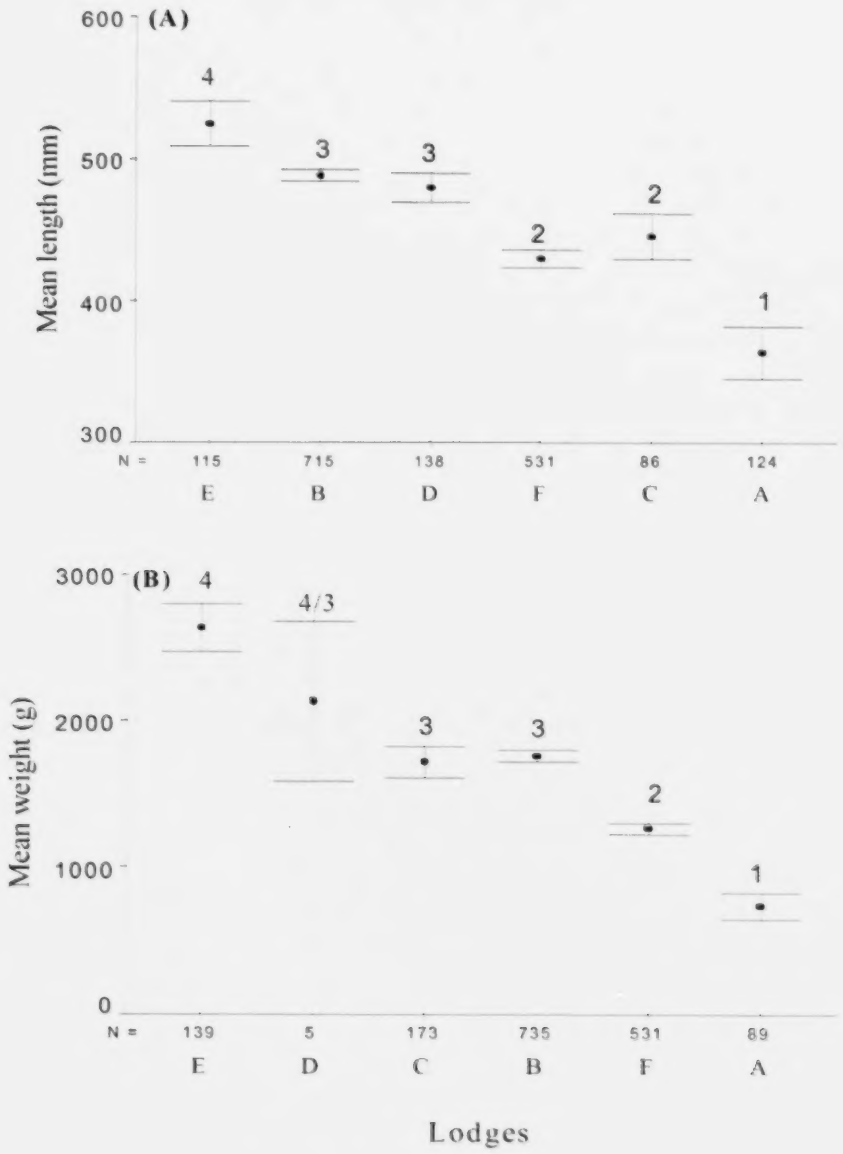

Figure 2. (A) Mean fork lengths and (B) whole weights of captured brook trout compared by lodge. Bars represent the 95% confidence intervals around the mean estimates. Numbers on top of the bars represent groupings of similar lakes.

Fork length measurements were used to calculate the proportional stock density (PSD) of each size class for all lakes sampled (Table 6). Chi-square analysis was performed and showed a significant difference between the PSDs for the lakes sampled. (X^2= 6.841, P<0.001).
Table 6. Proportion of stock in each size group from the lodges catch (Groupings are based on 10 centimeter fork length intervals.)

Lodge	0-10	11-20	21- 30	31- 40	41- 50	51- 60	60-70
A	---	2.46	17.21	47.54	18.03	14.75	0.00
B	---	0	0.42	5.73	47.41	45.59	0.84
C	---	0	0.00	21.43	35.71	42.86	0.00
D	---	0	1.45	6.52	50.72	40.58	0.72
E	---	0	1.72	4.31	30.17	43.10	20.69
F	---	0	3.22	24.05	56.25	16.29	0.19
Average	---	0.41%	4.00%	18.26%	39.72%	33.86%	3.74%

In general, the largest portion of the catch composition, for all lodges, falls between 40 and 60 cm. These groupings also emphasis the smaller fish size at Lodge A with 60% of its fish being in the 20 to 40 centimeter categories, and the larger fish at Lodge E with over 20% of its fish falling above 60 centimeters

The ANOVA results indicate a significant difference ($P<0.001$, $F=22.699$) exists in the mean catch rates for the six lakes. The post hoc test demonstrated that the catch rates could be divided into two sub groups with Lodge F having significantly higher catch rates (1.97 fish/hr) than the other five lodges (0.64 fish/hr) (Fig. 4).

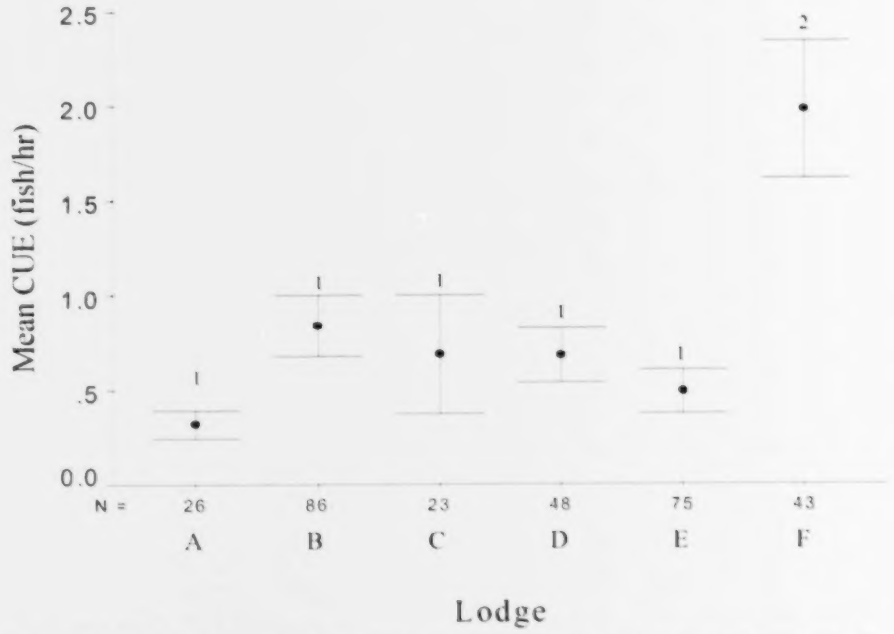

Figure 3. Mean catch per unit effort (CUE) for each lake sampled during the study period. Bars represent the 95% confidence intervals. Numbers above the bars represent the catch rate grouping.

WATER CHEMISTRY COMPONENT

Using EcoWatch software water chemistry parameters were compared and showed little variations from normal (Table 7). Ph levels were slightly acidic in Awesome Lake with a mean value of 6.19 falling just below the standard of 6.5–9. Dissolved Oxygen measures were not usable due to problems with the sensor. Specific conductivity values were low indicating the lakes are not nutrient rich (Trippel 1993; Donald et al. 1980).

Table 7. Descriptive statistics for water chemistry parameters collected between July 10, and July 24, 2007. All means calculated using temperatures measured at 1m intervals depths

Temperature °C	Awesome	Crooks	Eagle	Igloo	Osprey	Park
Mean	11.88	17.50	16.77	18.46	19.01	17.96
Minimum	5.50	17.22		17.63	17.95	16.27
Maximum	17.55	17.79	16.81	19.74	20.65	21.21

Specific Conductivity mS/cm	Awesome	Crooks	Eagle	Igloo	Osprey	Park
Mean	0.0080	0.0227	0.014	0.019	0.0127	0.009
Minimum	0.0060	0.0100	0.014	0.016	0.0100	0.008
Maximum	0.0250	0.1010	0.015	0.042	0.0480	0.011

pH	Awesome	Crooks	Eagle	Igloo	Osprey	Park
Mean	6.19	6.76	7.21	7.03	6.55	6.79
Minimum	5.60	6.53	6.82	6.60	6.28	6.61
Maximum	7.34	7.20	7.26	7.35	7.10	6.96

LAKE ATTRIBUTE COMPONENT

Bathymetry and spatial data were used to determine the following lake attribute data (Table 8) and produce three dimensional bottom renderings and depth contour maps (Appendix A). In general all sampled lakes are very shallow with mean depths ranging between 1.19 m and 4.45 m. Temperature profiles of five of the six lakes surveyed indicated lakes were homothermic.

Table 8. General lake attribute data for all study lakes collected between July 10, and July 24, 2007.

Lake	Max Depth (m)	Mean Depth (m)	Surface Area (m^2)	Volume (m^3)	Perimeter (m)
Eagle	2.87	1.19	8561500	10188185	48228
Park	6.55	1.95	50193900	97878105	211405
Crooks	7.41	3.38	18330300	61956414	39861
Osprey	3.54	2.10	9650430	20265903	67838
Igloo	5.00	2.62	11448100	29994022	39300
Awesome	25.27	4.45	4228620	18817359	211405

DISCUSSION

To date, the mark-recapture work has been inconclusive. Of the six lakes surveyed we could only obtain a reliable population estimates with reasonable confidence limits, for one population. As this was only the second year of the project further study is required.

The proportional stock density (PSD) analysis, which describes the general size structure, indicates the predominance of the angled catch is skewed to the largest fish (70% above 40 cm). Additional information provided from our standardized gill net sampling program indicates that the mean age of these populations tends to be older then brook trout populations sampled from the island (Wildlife Division unpublished data). In general, mortality also appears to be lower when compared to trout populations sampled from the island portion of the province (Appendix B). The higher mean age and lower mortality can probably be attributed to negligible fishing pressure. Lakes of the Eagle River, until the road is complete, remain inaccessible and most lodges practice catch and release fishing only. Thus, the additive mortality due to angling is negligible. In general, brook trout sampled from the Eagle River watershed tend to be unique, in that most neighbouring watersheds do not produce fish of similar size (Appendix C). Therefore, it is not surprising that the highest percentage of brook trout sport fishing lodges (nine in total) are located on lakes within the watershed (Tourism Culture and Recreation pers.com).

In combination this information seems to indicate that fish populations from the Eagle River are in a climax state. Climax populations have been described as sparsely populated dominated by older fish and are highly vulnerable to over-exploitation (Power 1978; Johnson 1976).

Population estimates may be cause for concern as the new highway will create increased access and this will, most likely, result in increased angling pressure. Increased access has been reported as a major contributing factor to the collapse of other salmonid populations. It was reported that lake trout, *Salvelinus namaycush* populations collapsed subsequent to the creation of logging roads near a formally isolated lake in Ontario, Canada (Gunn and Sein 2000). Perry (2006) also reported a decline in lake trout stocks subsequent to the creation of phase I of the Labrador Highway which linked the towns of Churchill Falls to Labrador City and Goosebay. This linking created increased access to Lobstick Lake which in turn increased angling pressure to the area. Therefore, the new management zone created for the Eagle River watershed was justified and every effort must be made to ensure proper protection for the limited resource.

Water quality results indicate that the lakes of the watershed are low in productivity. Specific conductivity measures, which are an indirect measure of TDS, were low suggesting the lakes are oligiotrophic (Thomas 1986). In accordance with our bathymetric data these lakes are primarily composed of homothermic, shallow water habitat. In this type of habitat fish have limited opportunities to retreat from high temperature and therefore temperature refugia can become a limiting factor (Baird and Krueger 2003). This might be a possible explanation as to why numbers of commercially viable fish are low in that available habitat may be limited. This also may be an indication, in the future that climate change may play an increasingly important role in the health of the local brook trout populations (Fleebe et al. 2006; Meisner 1990). Other authors have reported the importance of temperature extremes in defining critical habitat for brook trout (Baird and Krueger 2003).

Perry (1998) discussed the many difficulties inherent in the logbook methodology when getting outfitting lodges to accurately record their catch. While many of these difficulties were addressed for this work, some still remain. The length of each lodge's season and the number of times fishing events occur varies in accordance with the number of guests in a season. Therefore, the opportunities for tagging events varied among the lodges. This contributed to the weak confidence limits surrounding our population estimates at two of the lodges. Lodge A marked only 48 fish and Lodge C only marked seven fish, this resulted in a broad estimate for Lodge A and not obtaining any estimate for Lodge C in 2007. Subsequently, population estimates should be repeated in later years to increase the confidence of the estimates and determine what level of precision is being achieved. Emphasis needs to be placed on increasing the numbers of fish marked and recaptured; therefore time should be spent in training additional guides in proper tagging procedures. Additional tagging will help to overcome problems related to infrequency of fishing trips.

It is interesting to note that during the course of the study period, two tags were returned to our office by anglers from areas falling outside the lakes where they were initially marked. In one instance, the fish was recaptured in a lake that was 12 km from its point of origin. In the second instance, the tagged fish was recaptured 8 km from the original tagging location. Both examples, give cause for concern as they may indicate that some of the assumptions inherent with the mark and recapture methodology may have been violated. Specifically, the assumption that there is no immigration nor emigration from the population being assessed may have been violated (Ricker 1970).

The initial results from the logbook program suggest that brook trout inhabiting the Eagle River watershed are in mature climax state. Where mortality rates are low and fish are, on average, older. These populations tend to be vulnerable to increases in angling pressure. As most of these lakes fall within 30 km of the new highway, they are particularly vulnerable to increased exploitation. Therefore it would appear that the establishment of the new management zone for the Eagle River watershed was justified. However, it will not matter what management regime is in place if there is not an appropriate level of enforcement to accompany and support the newly established management regime.

RECOMMENDATIONS

1. The creation of the Eagle Plateau Management Zone in 2007 will only be effective if the regulatory changes are enforced through a strong enforcement program. Therefore consideration should be given to an increased enforcement presence for the area subsequent to the completion of the highway.

2. Continuation of the project. The data acquired during the first year of the project was valuable and highlighted some areas for increased attention in upcoming years. With increased effort population estimates can be improved. Continuation will allow for more baseline data to be collected, increasing sample sizes and also allowing for close monitoring in the first years of increased access to the Eagle River area.

3. Further collections of lake attribute data. To increase the knowledge and assessment of thermal habitat volume and available habitat, further work should be done on the collection of attribute data such as bathymetry and water quality parameters.

4. Broadening of the study area. It would be beneficial to expand the study to include additional outfitters in this, and other areas, to allow for comparison throughout the industry and monitor the resource and its utilization.

5. A radio tagging study should be initiated to determine the amount and distance of movement that is occurring for brook trout in the various populations and the amount of potential mixing that is occurring among the populations.

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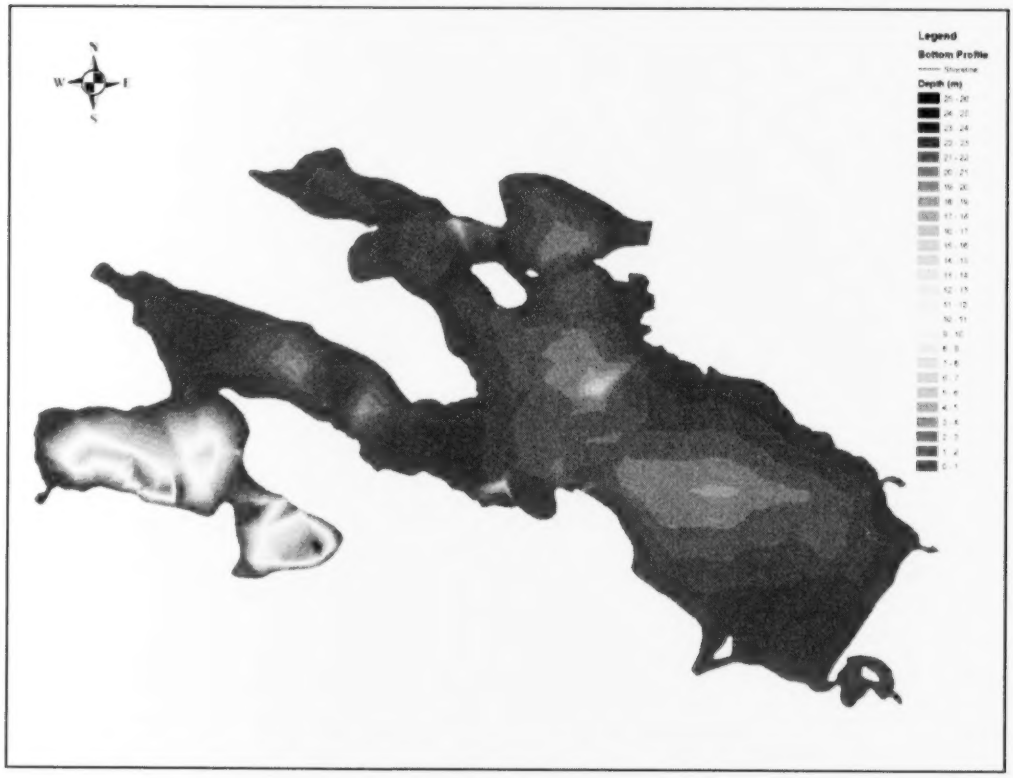
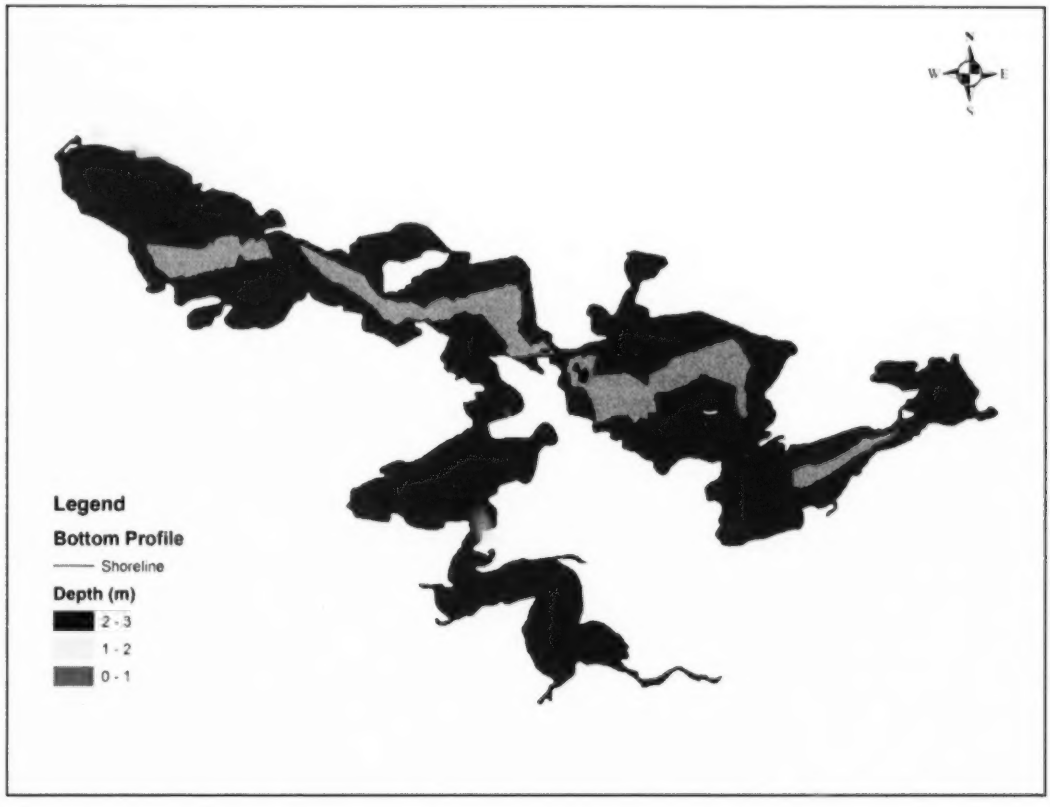
APPENDIX A

Bathymetric maps (Depth contours) for all lakes involved in the logbook program. In general all sampled lakes are very shallow with mean depths ranging between 1.19 m and 4.45 m. Temperature profiles of five of the six lakes surveyed indicated lakes were homothermic.

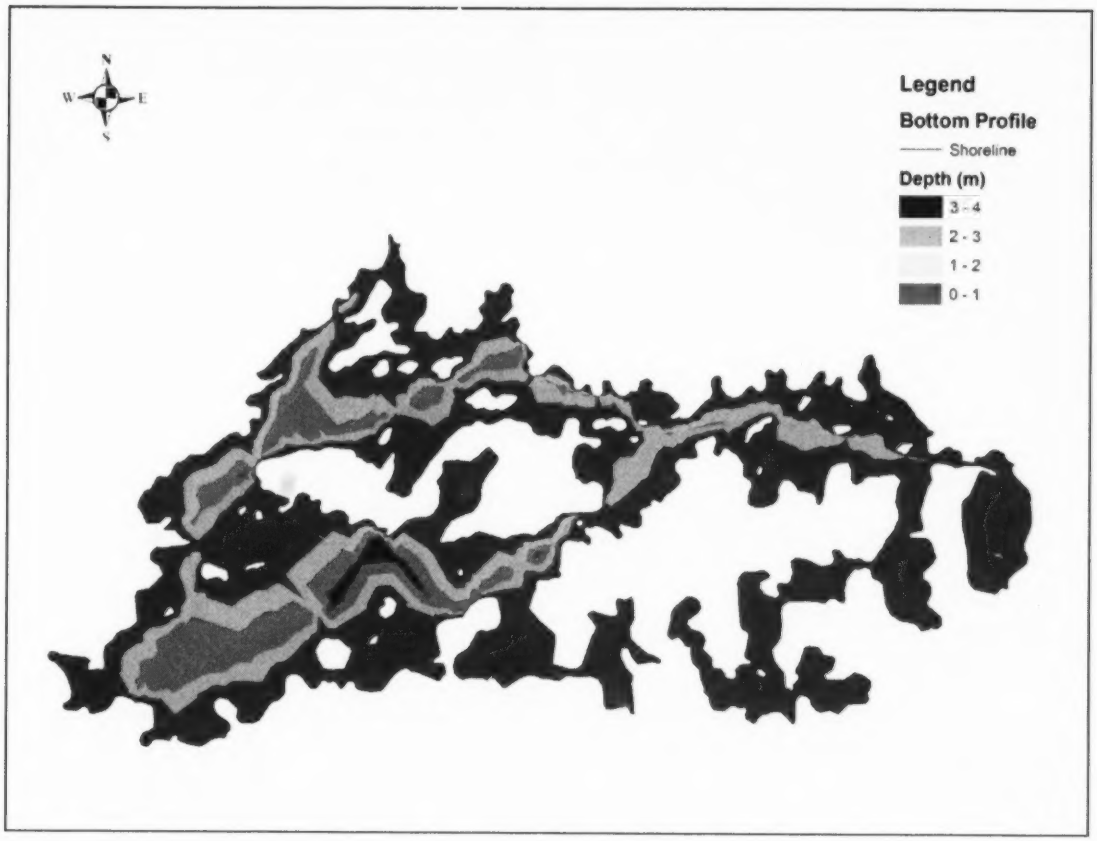
Awesome Lake



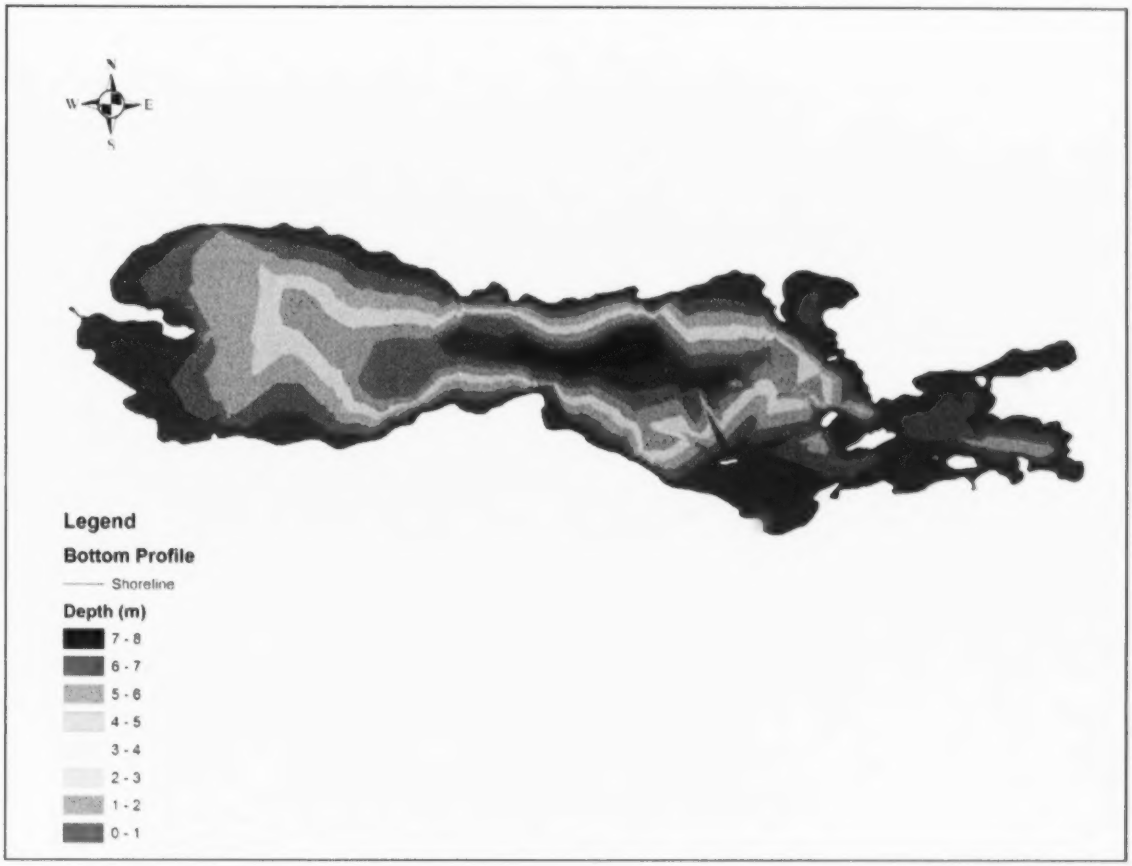
Eagle Lake



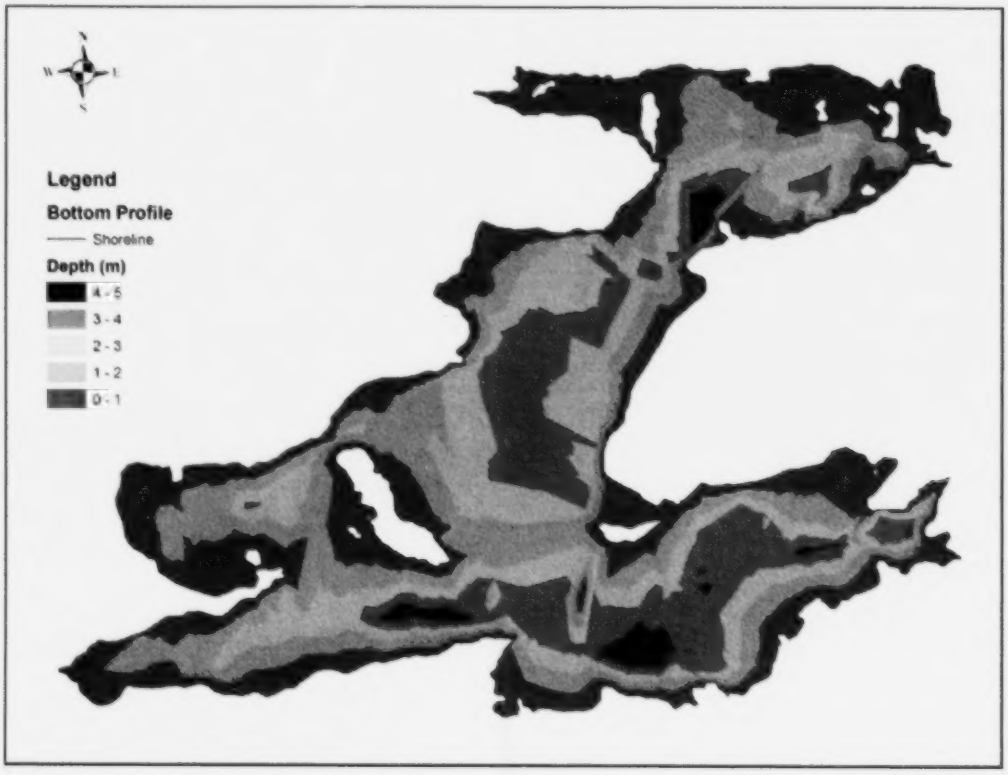
Osprey Lake



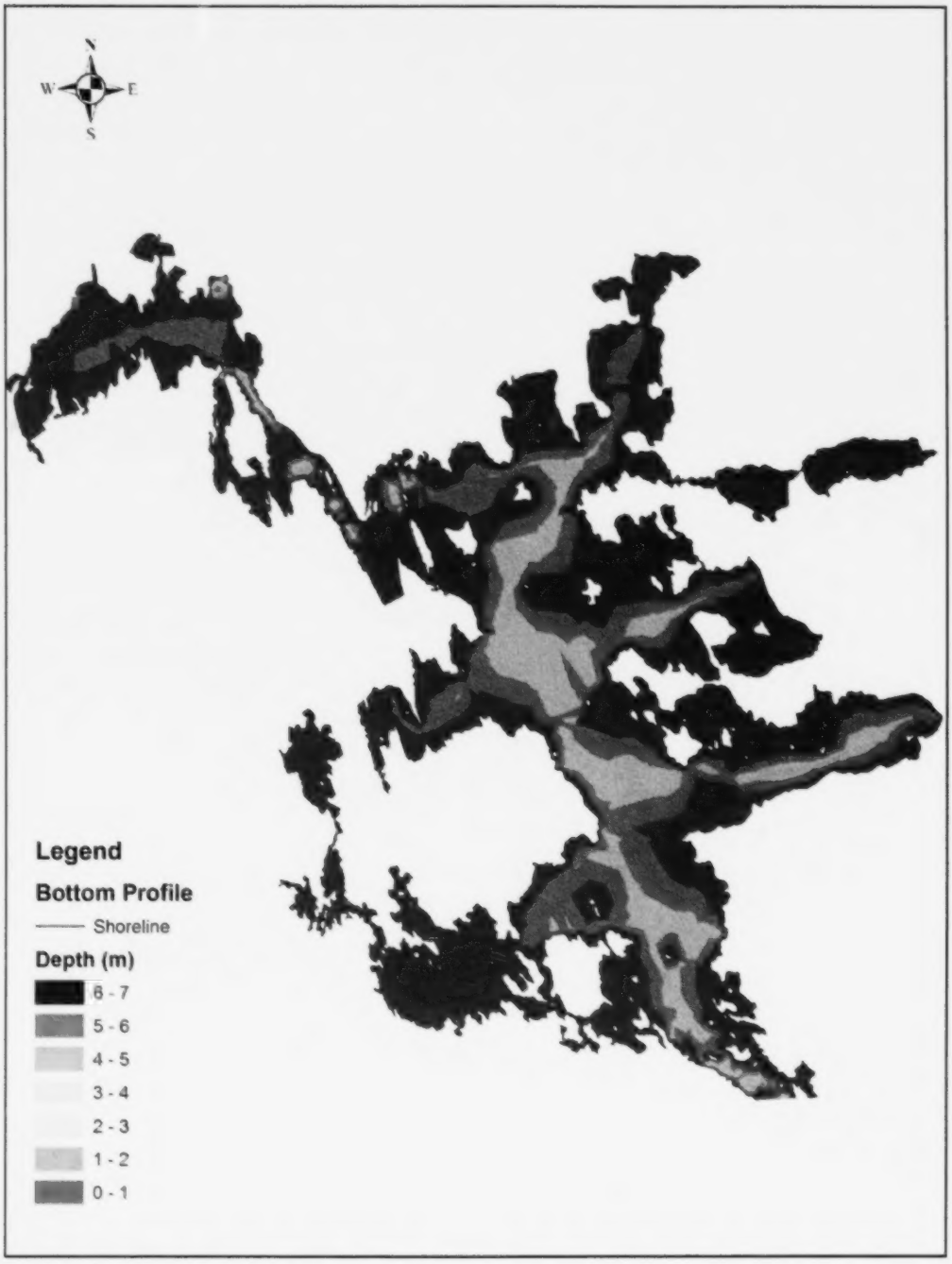
Crooks Lake


N
W
E
S
Legend
Bottom Profile
Shoreline
Depth (m)
7 - 8
6 - 7
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2
0 - 1

Igloo Lake



Park Lake

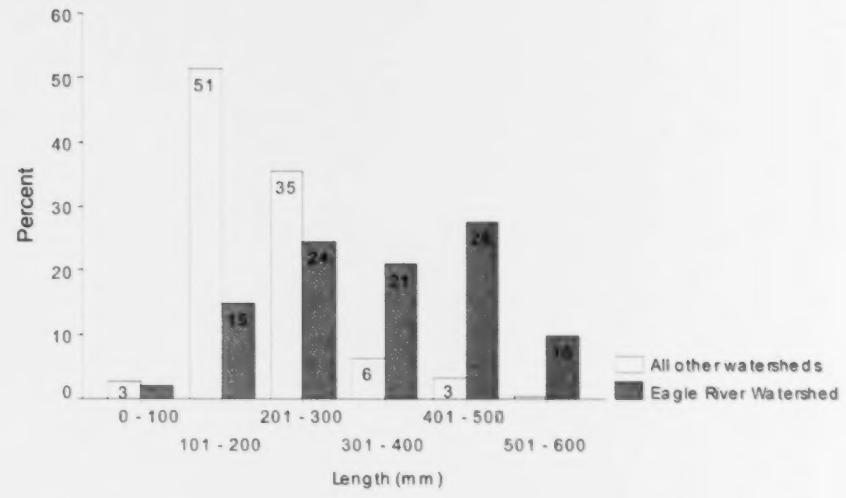

N
W
E
S
Legend
Bottom Profile
Shoreline
Depth (m)
6 - 7
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2
0 - 1

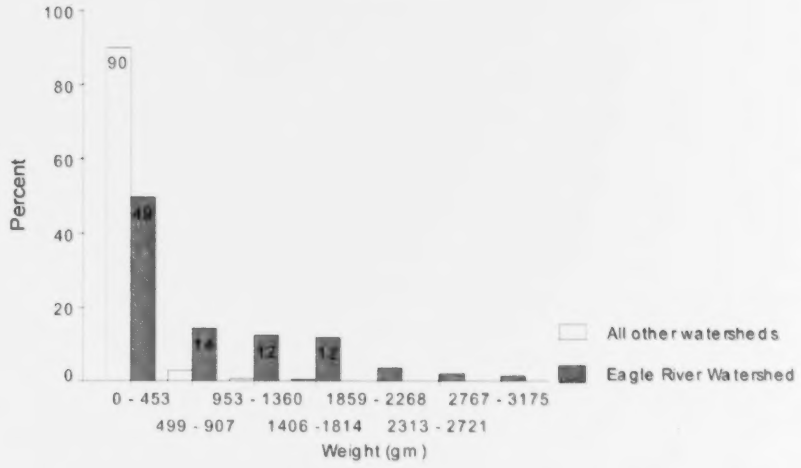
APPENDIX B

Table B: The mean annual mortality rates for brook trout sampled from four areas in Newfoundland and one in Labrador. Estimates were derived using the Chapman- Robson estimator. All samples were collected using a standardized stock assessment protocol. (CI) represents the 95% confidence interval around the mean estimates. (N) Represents the number of lakes used for the mean estimates.

Area	Location (N)	Annual Mean Mortality (CI)
Labrador	Eagle River	.3100
	(5)	(.3097, .4013)
Newfoundland	Indian Bay	.5900
	(13)	(.5144, .6656)
	Middle Brook	.6667
	(3)	(.5149, .8184)
	Jonathans	.5400
	(3)	(.4260, .6540)
	Avalon	.6616
	(12)	(.5981, .7250)

APPENDIX C





A comparison of all sampled fish from five randomly chosen lakes of the Eagle River (N = 196) to fish sampled from all other watersheds (N = 1103). Samples were collected using a standardized netting program. (A) Represents length and (B) weight groupings for all sampled fish. Other watersheds where lakes were randomly chosen include: Paradise (3), Travespine 1) Gilbert (2), Kenamu (2) Alexis (3), St Mary's (1), Augustine (1).